Cognitive Issues Related to Moving-map Displays in Military Aircraft

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June 13-14, 2002

Outline

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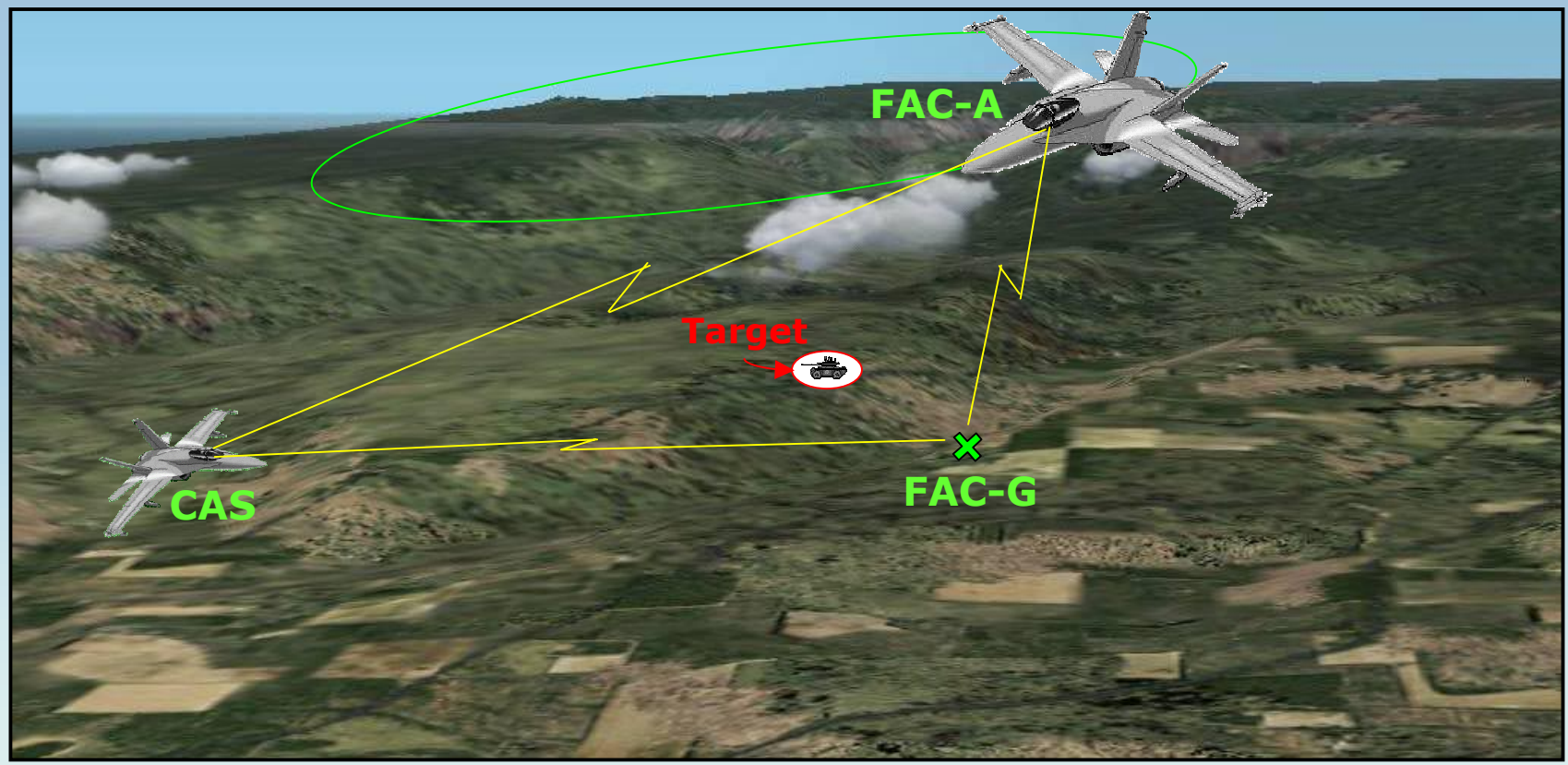
- Approach
  - *Pilot interviews*
  - *Process model*
  - *Sample moving-map displays*
  - *Planned experimental design*
- Summary

Introduction

- **Background:** at Naval Research Lab, improving cockpit moving-map displays for Navy pilots.
- **Critical issue** in naval air missions: transition from primarily internal (head-down) to external (head-up) guidance, based on preliminary human factors analysis.
- **Goal:** how to improve this transition with better moving-map display.
- **Parallel to civil aviation:** IFR approach (transition from head-down in clouds to head-up below ceiling). Most critical during circling approach.

Mission

Mission being considered for evaluation:
Forward Air Control (FAC) / Close Air Support (CAS)



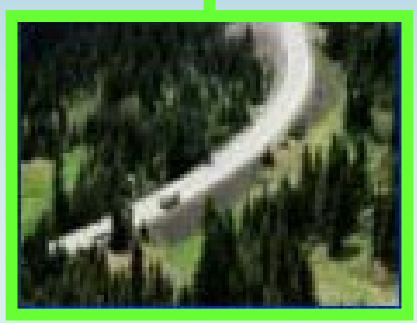
Pilot Interviews

- **Purpose:**
  - *Informal task analysis*
  - *Gain insights into mission goals, information requirements, current problems, potential solutions, etc.*
- **Interviewed 3 F/A-18 pilots at Naval Air Warfare Center (NAWC), Pax River, MD:**
  - *1 project officer for new cockpit moving-map display system (Pilot in command: 1200 F/A-18 hrs, 1700 total flight hrs)*
  - *1 experienced combat pilot: 24 missions over Iraq (PIC: 800 F/A-18, 1400 total flight hrs)*
  - *1 medical doctor / pilot (PIC: 700 F/A-18, 4500 total flight hrs)*
- **Initial interviews in person (~1 hour each)**
- **Follow-up telephone interviews (continuing)**
- **May add more pilots (different insights, ideas)**

Primary Channels of Information

Internal (head down) view: cockpit instruments, moving-map display

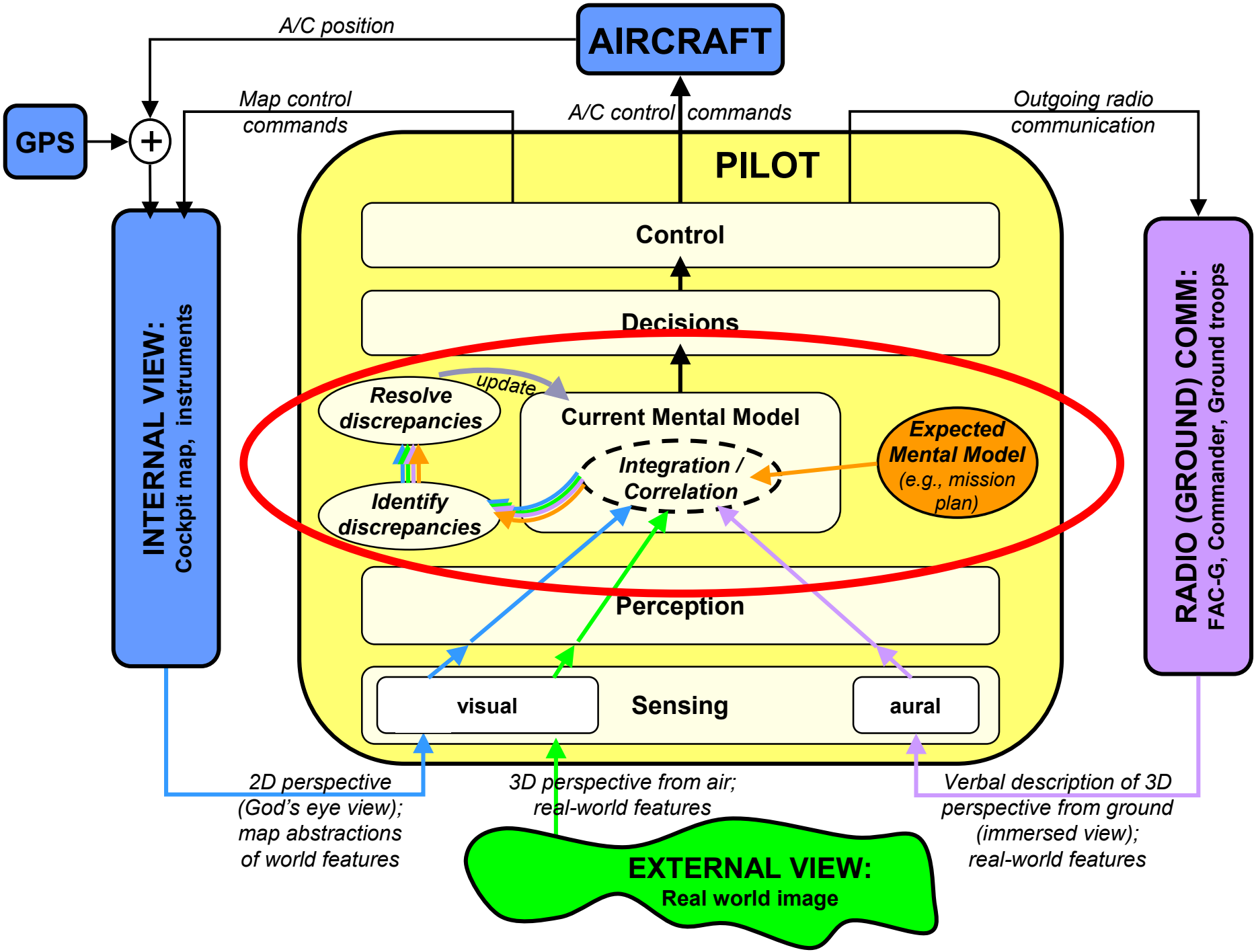
Audio: radio communication (FAC-G, FAC-A)



External (heads up) view: “real world” environment

Process Model

The following model is preliminary (still in development) …


AIRCRAFT
A/C position
GPS
Map control commands
A/C control commands
Outgoing radio communication
PILOT
Control
Decisions
update
Resolve discrepancies
Current Mental Model
Integration / Correlation
Expected Mental Model (e.g., mission plan)
Identify discrepancies
Perception
visual
Sensing
aural
INTERNAL VIEW:
Cockpit map, instruments
RADIO (GROUND) COMM:
FAC-G, Commander, Ground troops
2D perspective (God's eye view); map abstractions of world features
3D perspective from air; real-world features
Verbal description of 3D perspective from ground (immersed view); real-world features
EXTERNAL VIEW:
Real world image

Sample Information From Each Channel

INTERNAL VIEW

EXTERNAL VIEW

RADIO COMM

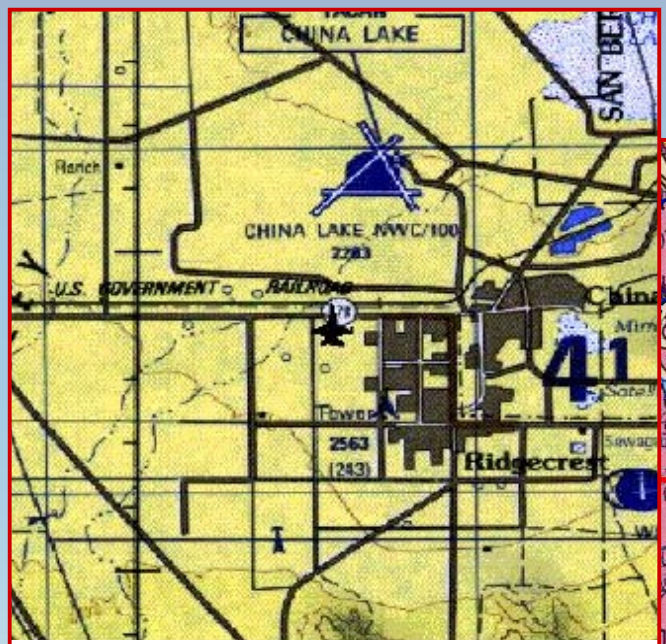
* **Terrain features:**
c = contour lines
fc = filled contours
s = shaded relief
? = not always reliable

* **Airports:**
r = runways shown
p = simple point

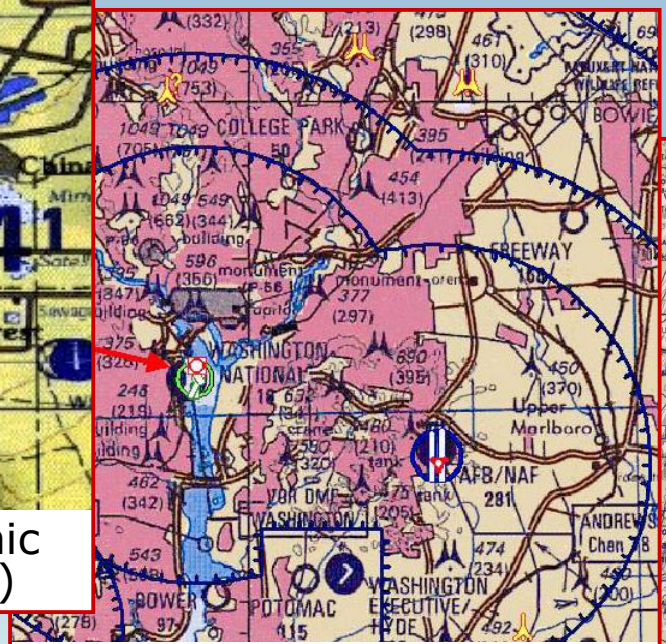
Examples of each channel

Source	Sensory	View	Feature Representation	Geographic Features: Areas: Terrain*	Urban	Farms	Vegetation	Lines: Roads	Railroads	Rivers	Coastlines	Points / Text: Airports*	Airport names	City names	High elevations	NAVAIDS	Mission Overlays: Threat rings	HAT	CLOS	No-fly zones	Routes	Own-ship pos'n	Targets	Waypoints
2-D Maps	**Visual**	**"God's Eye View"**	**Abstractions**																					
JOG-A (1:250k)				fc	x		x	x	x	x	x	r	x	x	x	x	x	x	x	x	x	x	x	x
TPC (1:500k)				c	x		x	x	x	x	x	r	x	x	x	x	x	x	x	x	x	x	x	x
JNC (1:2M)				s	x					x	x	p		x	x	x	x	x	x	x	x	x	x	x
2-D Images	**Visual**	**"God's Eye View"**	**Photo-like reproductions**																					
Satellite imagery				?	x	x	x	x	x	x	x	r					x	x	x	x	x	x	x	x
Reconn. Photo				?	x	x	x	x	x	x	x	r											x	x
ATFLIR				?	x	x	x	x	x	x	x	r												
3-D Perspective	**Visual**	**Pilot's view from air***	**Real world**	?	x	x	x	x	x	x	x	r			?									
3-D Ground	**Aural**	**FAC-G view from ground***	**Real world**	x	x	x	x	x	x	x	x	p	?	?	?							x	x	

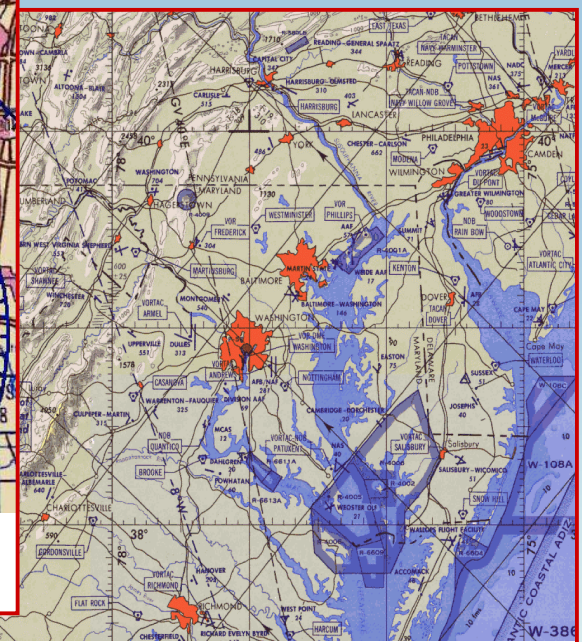
Sample Map Displays



Joint Operational Graphic (JOG) 1:500k (10 nmi)



Tactical Pilotage Chart (TPC) 1:500k (20 nmi)



Jet Navigation Chart (JNC) 1:2M (80 nmi)

Aeronautical chart data from National Imagery & Mapping Agency (NIMA)

Sample Image Displays

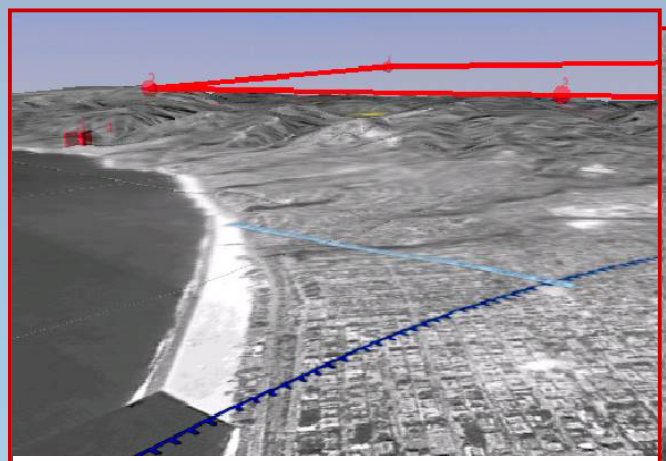
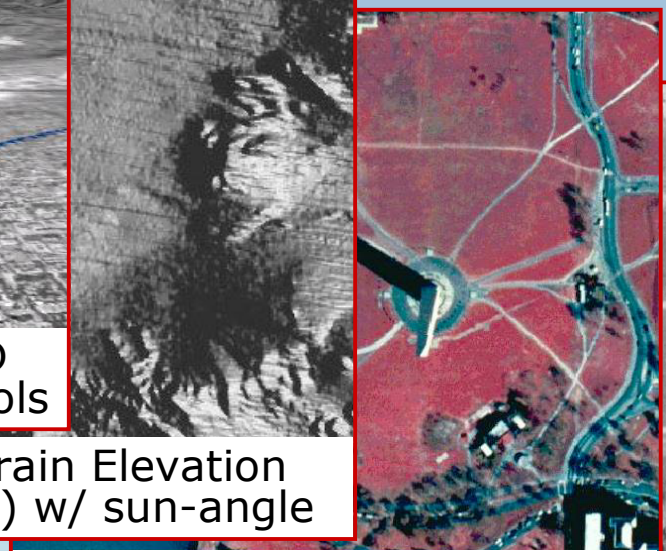
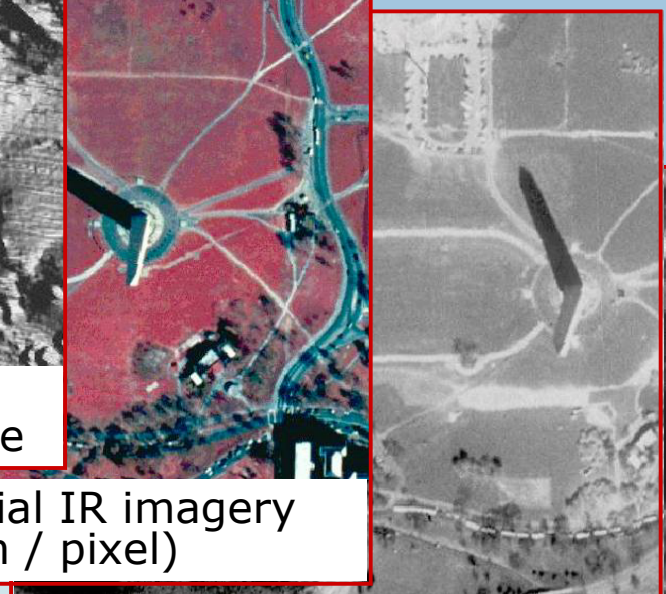


Image overlaid on DTED with route planning symbols

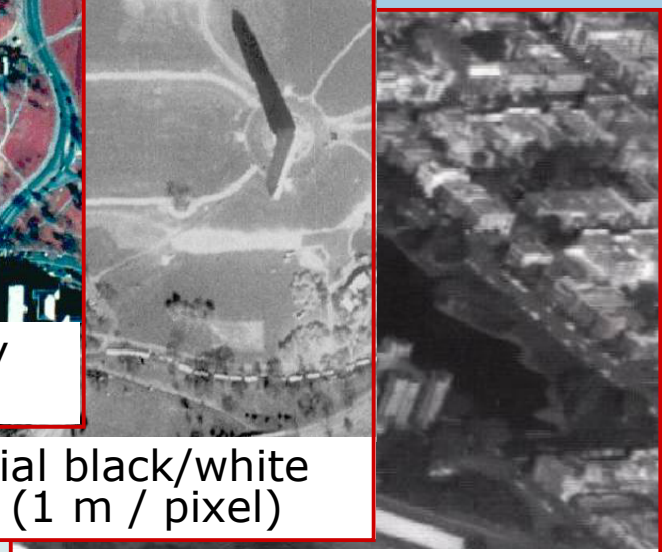
Digital Terrain Elevation Data (DTED) w/ sun-angle



Commercial IR imagery (1 m / pixel)



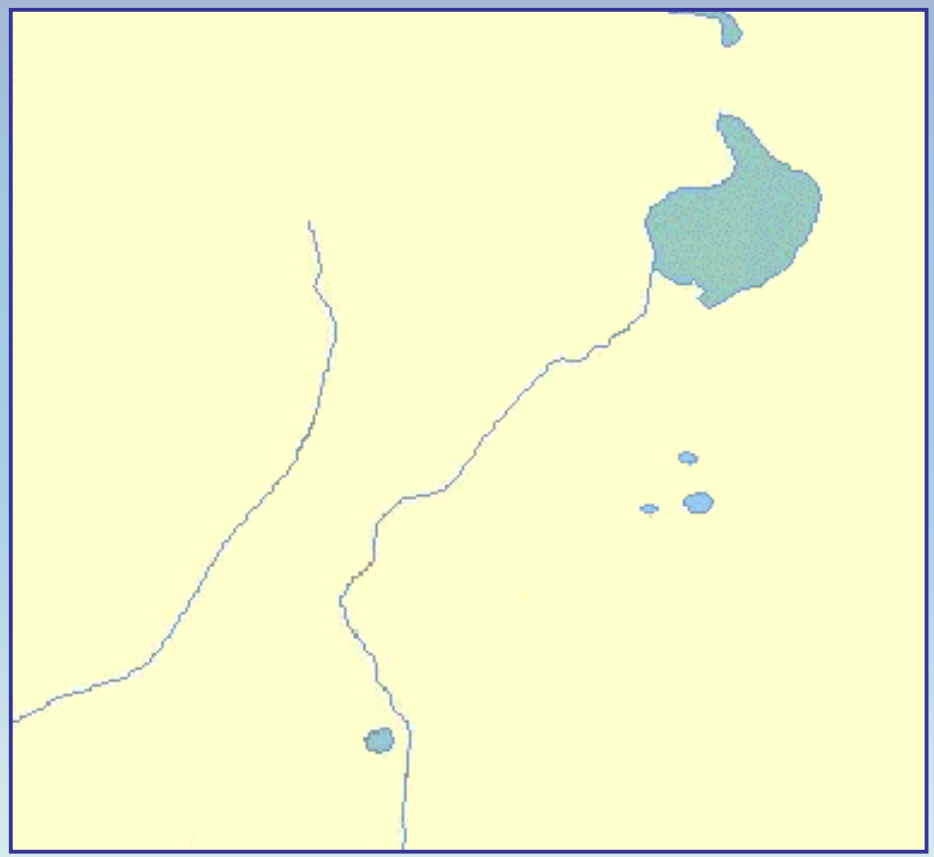
Commercial black/white imagery (1 m / pixel)



ATFLIR

Imagery from commercial and government (NIMA) sources

Sample Vector Map



- Information analysis indicates a need to remove extraneous information (“declutter”) during different mission phases (e.g.,target acquisition).
- Need to identify most important features to support transition between internal / external guidance.

Vector Smart Map (V-MAP) from NIMA

Issues to Investigate

- Which map features best support the transition between internal / external guidance phases?
- Mental rotation / transformation:
  Can the orientation (e.g., track-up vs. ingress-up) of visual information (e.g., map, reconnaissance photos) impact transition?
- How does scene bias / expectation bias affect the transition process?

Experiments Being Considered

- **Set up mock FAC / CAS scenarios:**
  - *MS Flight Sim (for external environment, internal cockpit)*
  - *NPFPS (for both mission planning and in-flight moving-map)*
  - *Participants (pilots) to act as CAS*
  - *Possibly play prerecorded pseudo-FAC commands (ATC-like)*
- **Experiment 1: identify map features that support transition**
  - *Provide pilots with maps at varying levels of detail*
  - *Test ability to make transition: speed and accuracy of target acquisition*
- **Experiment 2: study impact of mental transformations on transition**
  - *Provide pilots with reconnaissance photograph of target area at various orientations (e.g., from ground vs. from air; ingress-up vs. other view)*
  - *Test performance (as in test 1) at different levels of visibility (i.e., clear vs. cloudy conditions)*
- **Experiment 3: study effect of scene / expectation bias on transition**
  - *Provide pilots with information about target area during mission planning*
  - *Test performance when information is current and accurate vs. out-of-date or otherwise inaccurate*

Proposed Setup

- **MS Flight Simulator 2002** with WidevieW extension simultaneously running on 2-3 networked PCs showing high-resolution outside scene (forward view, possibly left and right) and flight instrument panel.
- **Navy Portable Flight Planning System (NPFPS)** on 4th PC receives "real-time" GPS latitude / longitude coordinates from MS Flight Sim to drive moving-map display. Also provides preflight route planning functions. NPFPS currently used by F/A-18 pilots in Joint Mission Planning System.

Sample Views

MS Flight Sim "Virtual Cockpit" top view

MS Flight Sim "Virtual Cockpit" forward view

Simulated real-world views from cockpit (MS Flight Simulator 2002)

Summary

- Navy pilots experience difficulties during transition between internal ←→ external guidance phases of target acquisition missions.
- Parallels exist between military target acquisition and civilian IFR runway acquisition.
- Preliminary hypothesis for thesis: tools to "synch" internal and external information paths will support communication / coordination among mission participants, improving transition phase and increasing potential for mission success.
- Designing experiments to test hypothesis this summer. Tools under investigation will utilize moving-map and head-up displays.